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TITLE: LOS ALAMOS PORTABLE BETA-RAY SPECTROMETER

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LOS ALAMOS PORTABLE BETA-RAY SPECTROMETER

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Abstract: The integration of a beta-ray detector to multichannel analyzer (MCA) and computer has resulted in a portable spectrometer for studying beta rays in the field. The present detector is a 5 cm diameter by 2 cm thick plastic scintillator manufactured by Bicron, Inc. Other detectors can easily be integrated into the package. The integral instrument package is 15 cm wide by 15 cm high by 25 cm long and weighs less than 10 pounds. Internal rechargeable batteries for 8 hours of field operation are included. The instrument contains a detector, an amplifier, a multichannel analyzer, and a liquid crystal display (LCD). A microprocessor controls all the functions of the instrument and is programmed to display all necessary information and 128-channel spectra on the LCD.

Introduction

The problems of beta dosimetry stem from the typically broad beta energy spectra encountered, and the energy-dependent nature of both detector response and dose distribution in tissue. The ideal survey instrument should be sophisticated enough to account for this energy-dependence and provide reliable dosimetry data regardless of the incident beta energy.

Small, portable radiation survey instruments with microcomputers for instrument operation and data analysis have been developed at Los Alamos for several applications (Wa81, Er82). We have recently begun development of a combination beta spectrometer/dosimeter with internal microprocessor for spectrum unfolding and conversion of fluence to absorbed dose versus depth in tissue. A small beta-ray detector built by Bicron, Inc. has been interfaced to an electronic system, including a 128-channel pulse height analyzer. The detector is capable of measuring the energy of beta rays from 100 keV to about 4 MeV. Work reported here involves the development of the electronic package and spectrometer functions.

Description of Electronics

The electronic circuits include an input circuit, a microcomputer, and display as shown in the block diagram in Fig. 1. The input circuit includes signal conditioning circuits and an 8-bit analog-to-digital converter (ADC). The output of the ADC is fed to the microcomputer, which will generate spectral and dose information. The microcomputer is designed around a National Semiconductor NSC 800 microprocessor. The processor is supported by 16K bytes of total memory. Spectral and dose information is sent to a built-in liquid crystal display (LCD). The LCD is arranged in a dot matrix array, 80 dots wide and 28 dots high.

The power to operate the instrument is supplied from six AA rechargeable batteries. Power consumption is low enough for the battery pack to provide about 8 hours of operation between charges.

Operation of the Instrument

Several different modes of operation are available on the instrument. They are 1) accumulate data; 2) display beta spectra; 3) display integrated dose results; 4) display dose rate results. While the raw data are being accumulated, the integrated dose and dose rate are updated periodically.

The LCD functions to display both alphanumeric data and graphics output. For example, the raw data are displayed as a plot of number of counts per channel versus channel. Only 80 channels of data are displayed at one time, and to display the remaining 48 channels the display can be scrolled. The x-axis is calibrated in MeV and the vertical scale can be changed to accommodate the data being displayed. All dose and dose rate results are displayed on the LCD. Fig. 2 illustrates the alphanumeric and graphic display in response to a Sr-90 beta spectrum.

All of the various modes of the instrument are accessed through a sixteen-button keypad. It is important to note that the complete operation of the instrument is controlled through the software developed for the instrument.

Spectrometer Performance

Preliminary calibration of the detector assembly has been performed with mono-energetic electron sources at Lawrence Livermore National Laboratory (150-630 keV), and at the U. S. National Bureau of Standards (150 keV - 2.5 MeV). Figure 3 illustrates a few of these measurements. The energy resolution (FWHM approximately 15% of the incident energy), and the backscatter tail are typical of plastic scintillators.

Detector response was recorded at several beta energies and at several angles of incidence. Results of these measurements are being used to determine the detector response function, which will be incorporated into an unfolding code for the integral microprocessor (Ha83).

The response of the detector to gamma and x radiation is not insignificant. Bremsstrahlung from incident beta particles will be compensated by the detector response function, but analysis of a mixed beta/gamma field will probably require a second, beta shielded measurement for subtraction of the Compton background.

Discussion

Our preliminary data indicate that a portable beta spectrometer/dosimeter is indeed feasible. The detector response is more than adequate for a survey instrument of this type. Once the spectrometer functions are fully characterized, we will begin development of algorithms for conversion of fluence to absorbed beta dose. These algorithms will be tissue depth-specific and, depending on user needs, will calculate and read out directly dose to selected targets (e.g. skin, lens of the eye).

Acknowledgements

We would like to acknowledge the generous help of Certes Graham at LLNL and Chuck Dick and Chris Soares at NBS in making the calibration measurements for the

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References

Er82 Erkkila, B. H., Waechter, D. A., and Vasilik, D. G., 1982, "A Portable Neutron Spectrometer/Dosimeter," The Ninth DOE Workshop on Personnel Neutron Dosimetry, Las Vegas, Nevada, 24-25 June, 1982

Ha83 Hajnal, F., 1983, "Beta Radiation Instrumentation: Short Review of Selected Computational Methods." International Beta Dosimetry Symposium, Washington, D. C., 15-17 February, 1983.

Wa81 Waechter, D. A., Wolf, M. A., and Umbarger, C. J., 1981, "Hand-held Gamma-Ray Gun," IEEE Trans. Nucl. Sci., NS-28, No. 1.

Figure Captions

Fig. 1. Block diagram of the instrument electronics circuits.

Fig. 2. Typical Sr-90 beta spectrum with illustrations of the alphanumeric and graphic displays from the instrument.

Fig. 3. Detector calibration measurements for three energies (375 keV, 1.0 MeV, and 2.5 MeV electrons).

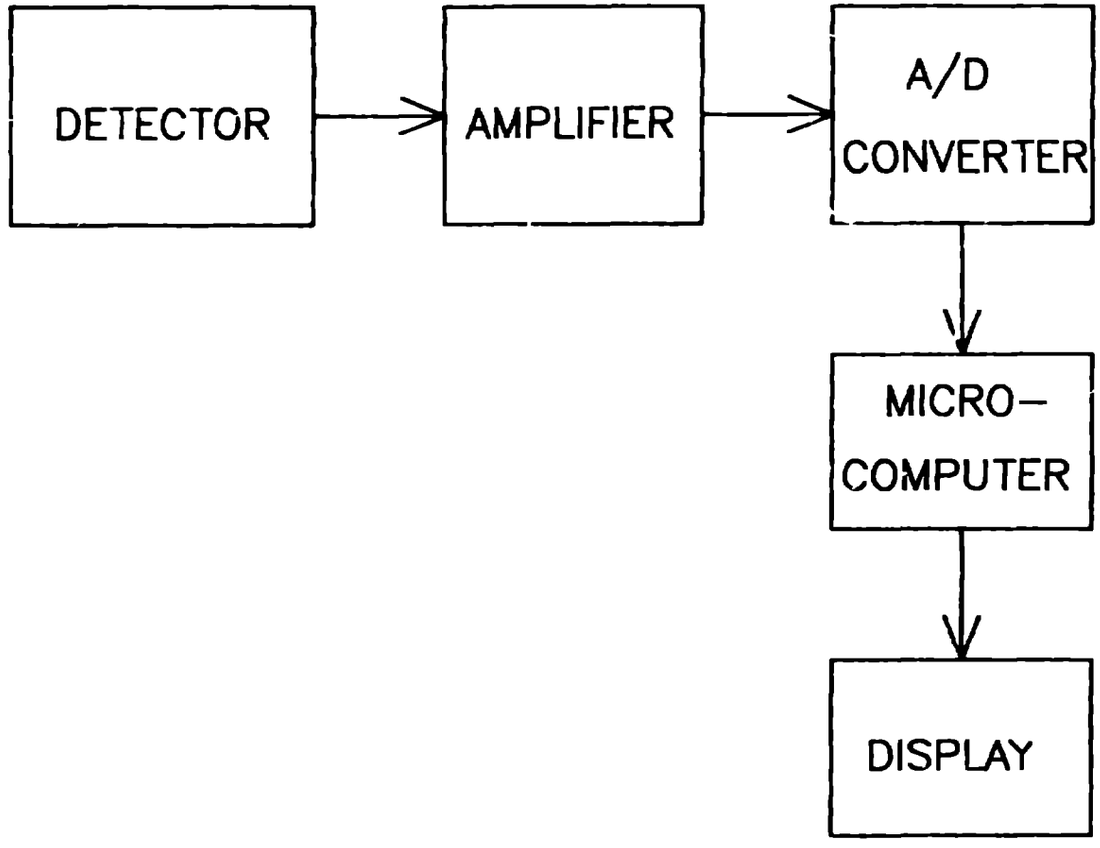
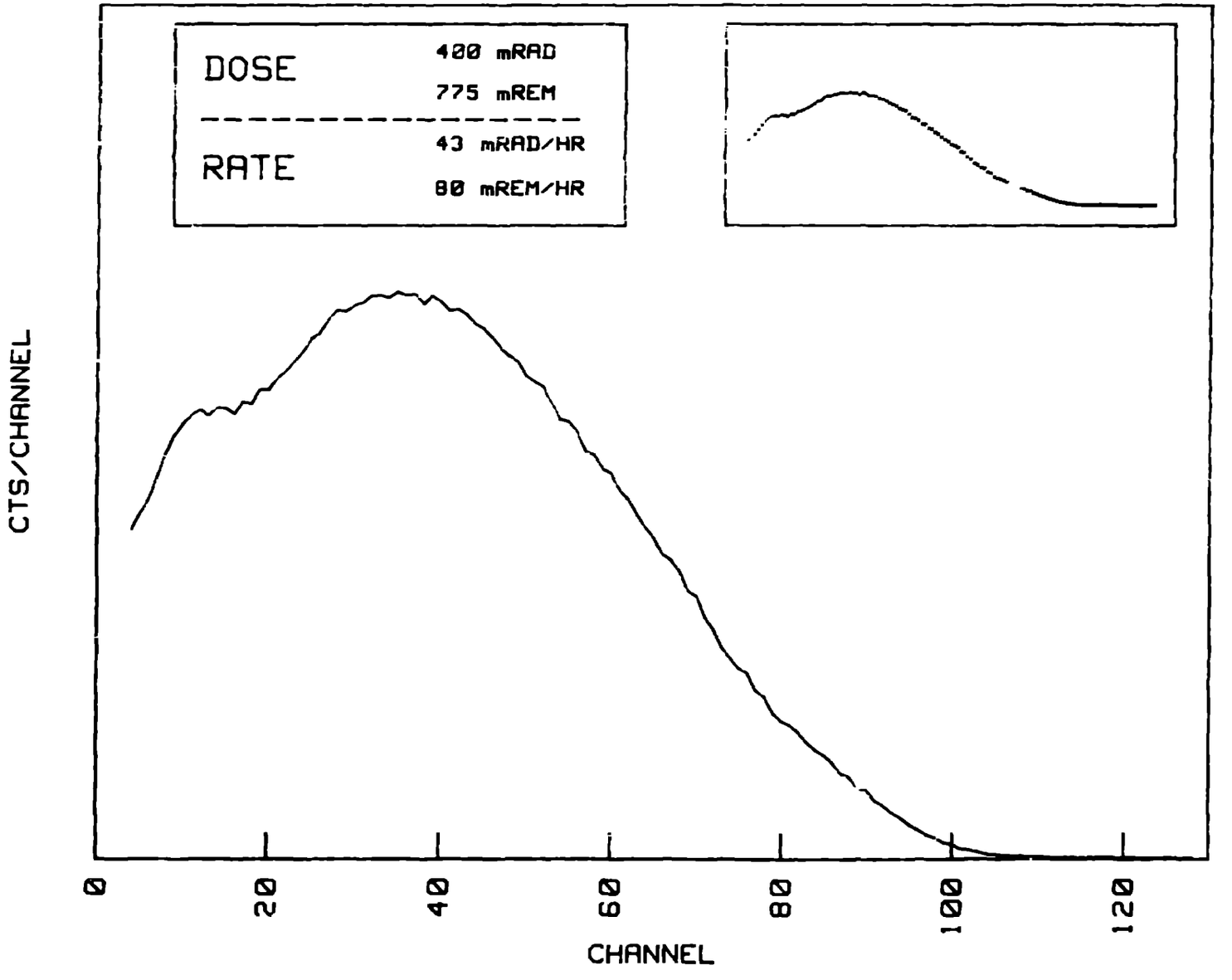


Fig. 1


DOSE
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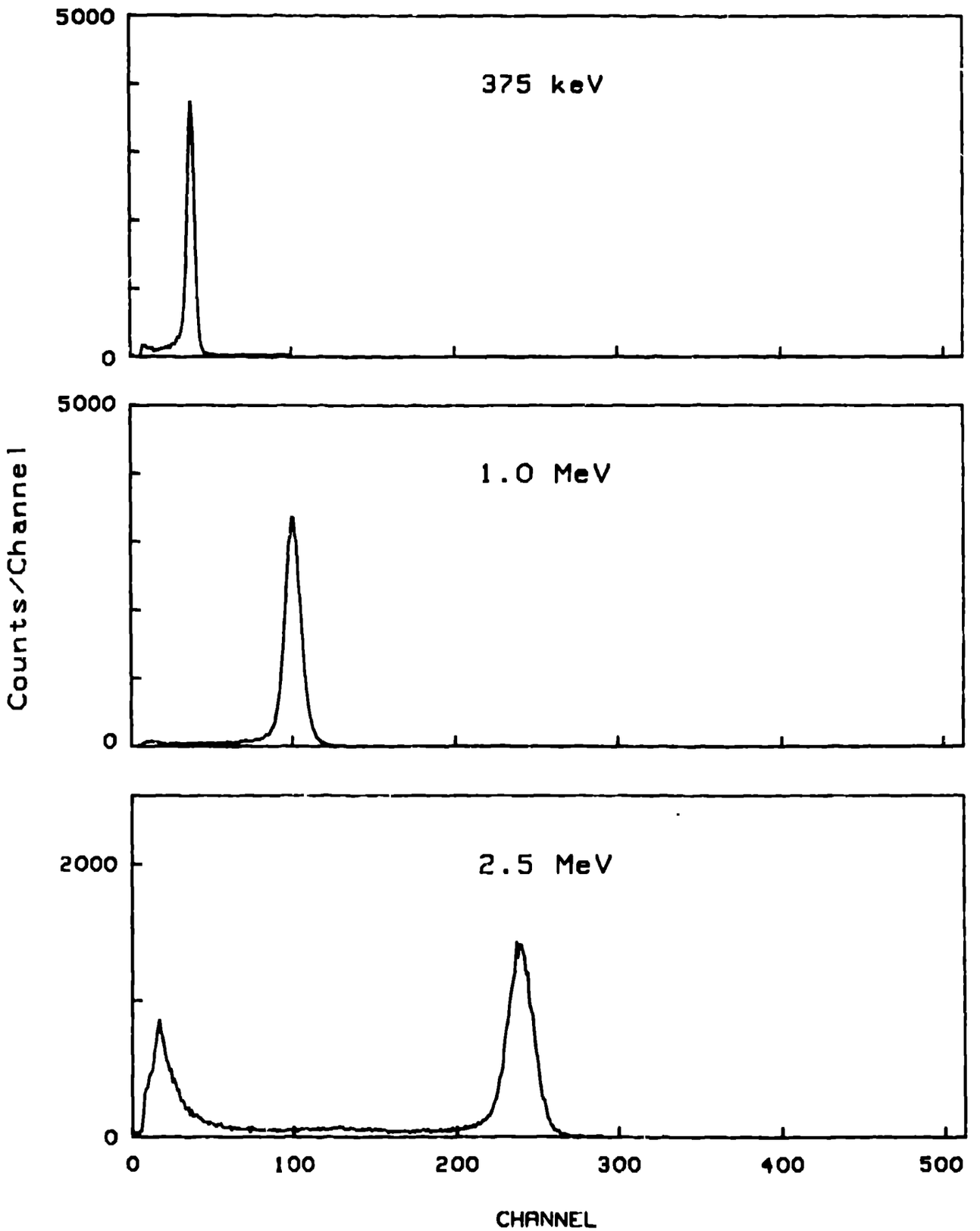
RATE
43 mRAD/HR
80 mREM/HR
CTS/CHANNEL
0
20
40
60
80
100
120
CHANNEL

Fig. 3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1.0 MeV
0
Counts/Channel
2000
2.5 MeV
0
0
100
200
300
400
500
CHANNEL

Fig. 3